Somes Bar Integrated Fire Management Project
Geology Report

December 27, 2017

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The Klamath National Forest Land and Resource Management Plan requires geologic investigations for vegetation-disturbing activities on potentially unstable lands, where potential geologic hazards exist, before the development of any new or existing rock or earth material quarries, and where there are potential impacts to cave and groundwater resources (USDAa, pgs. 4-18,19,20). Geologic investigations must include identification of geologically unstable lands, distribution of rock types and relevant structural features, geomorphic terrain with landslide potential, known special interest areas, caves, groundwater developments, and rock material quarries by use of existing databases, and include recommendations for additions or exclusions. Each geologic resource is addressed, and additional attention is given to unstable lands and treatments within unstable lands.

Geologic Setting

The project area lies in the west central area of the Klamath Mountains, which are comprised of sets of roughly parallel, north-south trending, arcing concave eastward belts extending from northwestern California through southwestern Oregon (Irwin 1989). The four focal areas lie within the Rattlesnake Creek and Hayfork Terranes of the Western Paleozoic and Triassic Belt, which are generally comprised of oceanic crust, volcanic island arcs, and mélange sediments that range in age from early Paleozoic to middle Jurassic (~500 – 170 million years ago). Subsequently, the rocks were tectonically fractured and the resulting terranes were successively amalgamated together during Jurassic time (~145 – 200 mya) to form the belts prior to their accretion onto the North American continent in the early Cretaceous (~120 – 145 mya). Among the rocks of volcanic and sedimentary origins are plutons of the same age and origin as their surrounding accreted terranes, as well as younger, post-amalgamation intrusions. An erosional period starting around 6 mya allowed the formation of the Klamath peneplain, a thick soil developed sub-aerially prior to the uplift of the Klamath Mountains to their present elevations during the middle Pleistocene (~0.25 – 0.75 mya, Irwin 1997, Aalto 2006). Rocks are generally younger westward with terranes bounded by eastward dipping, imbricate thrust faults, but complex structural relationships confound this simple model. The Klamath River canyon follows the north-south orientation of the terrane-bounding faults. This long and complex history has caused ubiquitous, but varying degrees of metamorphism resulting in sheared, deformed, and fractured rocks.

Bedrock

Lithologies include metavolcanics and metasediments with minor amounts of intrusive rocks (granitics and gabbros) and ultramafics. Some geologic units, notably the Rattlesnake Creek terrane, consist in part of highly mixed mélanges, which are frequently subject to slope instability and deep-seated mass movement. Also, numerous terrane-bounding thrust faults cross the area, in a general north-south orientation, and shearing with associated rock incompetence and instability is pervasive. Areas of highly sheared rock generally correspond with zones of deep-seated instability and landsliding, including several large earthflows and prehistoric large landslides.

Geomorphology

The active, deep inner gorge canyon of the Klamath River, steep upland topography, as well as the noted disrupted and sheared nature of much of the bedrock, combined with high rainfall-runoff effects in the wet Mediterranean climate, combine to effect high rates of mass movement (landsliding) and sediment delivery in the project area. Episodic flood events erode the toe zones of inner gorge landslides in the Klamath River corridor and within major tributary gorges such as Stanshaw, Sandy Bar, Ti, Kennedy, Rogers, Teneyck, Natuket, and Donahue Flat Creeks. These storm driven movements on inner gorge landslides often activate larger features that extend into upper hillslope positions. Major floods in 1955, 1964, the 1970's, 1986, 1995 and 1998, have resulted in extensive landslide delivery to the Klamath River, often damaging or removing Highway 96. Large prehistoric landslides are evident in all four focal areas. Of these, the Ti Bar earthflow has by far the greatest contemporary activity and concerns for project-related effects. Deep-seated landsliding in the Ti and Rogers Creek areas is largely associated with shearing along faults and inner gorge activity. The Donahue Flat and Patterson focal areas are largely occupied by large prehistoric landslides that are and are expressed as landscape scale, low gradient benches. Mostly dormant now, they exhibit characteristics of dormant earthflow terrain such as frequent springs, hummocky terrain, and broad steep concavities with well rounded, deeply weathered breaks in slope without abrupt scarps. All landslides that have potential to impact watercourses were mapped and included in riparian reserves as is required by the Klamath and Six Rivers Land and Resource Management Plans (USDA 1995a, pg 4-106; USDA 1995b, pg IV-44). Features included active shallow landslides inner gorges, toe zones, and areas within earthflows with evidence of activity within the past 400 years (USDA 1994) such as bowed and leaning trees, abrupt scarps, tension cracks, disorganized and incised stream networks, and sag ponds. Also included were dormant portions of some of the largest deep-seated earthflows in order to capture entire features.

Caves, Mines, Fossils, and Groundwater

Majority of fossil bearing limestone rocks are in older rocks outside of the focal areas. Although radiolarian bearing chert may exist within the focal areas, these are not significant fossil resources (Irwin 1989). There are no significant caves, mines or quarries that will be influenced by the project. There are no developed groundwater sources in the project area. Other groundwater resources will not be impacted as springs and riparian areas excluded heavy equipment and therefore compaction that can alter groundwater patterns and flow. Where compaction on temporary roads or landings poses a potential impact to groundwater, surfaces will be ripped to restore infiltration.

Naturally occurring asbestos

Six Rivers National Forest has no samples or tests for presence of Naturally Occurring Asbestos within the project area. Six Rivers National Forest data map ultramafic rock in the northwest quadrant of the Ti Creek focal area. However, these data disagree with other published geology maps for the area (Irwin 1994, 1997). Field observations support the other published maps, and revealed that exposed soils in the area are composed of Klamath peneplain, a reddish orange, and clay rich soil not associated with naturally occurring asbestos. In the southern section of the Patterson focal area exist ultramafic and serpentine bedrock that is not mapped. No mechanical treatments will be applied, and no temporary roads used within the ultramafic and serpentine bedrock there. Strategic firelines are planned in the Patterson serpentinite area, but they are fuel breaks and not handlines.

Unstable Lands

Geologically unstable lands are defined as active landslides, all inner gorges, margins and toe zones of dormant landslides, and severely weathered and dissected granitic lands. Land and Resource Management Plan standards and guides require management of vegetation on geologically unstable lands to "maintain or enhance slope stability and soil productivity according to Riparian Reserves standards and guidelines," (USDAa, pg. 4-18, and glossary pg. 9). This is because landslides are a key component of the riparian system, supplying and metering sediment and large wood that are essential habitat elements of Pacific Northwestern river systems.

Riparian Reserves, as a part of the Forest Plan Aquatic Conservation Strategy (USDA 1994a, pgs. 4-25, 26, 27) must meet the Aquatic Conservation Strategy objectives which direct management activities to result in non-degradation and restoration of aquatic and riparian ecosystems. In order to meet Aquatic Conservation Strategy objectives, vegetation management activities follow several sets of guidelines including Land and Resource Management Plan standards and guides, best management practices (BMPs, USDA 2010), and project design features. These guidelines are incorporated into project analyses and design, and provide a set of practices which, during project implementation allow for both accomplishment of project objectives, and maintenance and restoration of riparian function and condition. Because of these prescriptive methods, vegetation management within all unstable lands meet Aquatic Conservation Strategy objectives as project activities do not accelerate mass movement above background rates. This is largely achieved by restricting mechanical vegetation management to outside of unstable lands.

No mechanical vegetation management activities are occurring on the geologically unstable lands defined above. Mechanical treatments occurring on areas mapped as unstable lands occur only within the dormant sections of deep-seated earthflows, are very minimal in area, and use low impact ground-based, road-based and cable methods. To put into perspective the extent to which mechanical treatments will occur on the relatively stable portions of mapped unstable lands, we can examine their place among all mechanical treatment units, and their place within the four treatment units where mechanical treatments within the dormant portions of large earthflows will be performed. In the following discussion, the term "unstable lands" refers to the dormant portions of earthflows where mechanical treatment are planned.

First, the total area of all 106 mechanical treatment units is 1,420 acres (see Table xx). Of that, only four units lie within the dormant portions of large earthflows. Those four unit total 32 acres and area of unstable land within the four units is 31 acres. Among the unstable lands within those four units, only portions will have mechanical treatments. The total area of unstable lands receiving mechanical treatments is 15 acres. The 32 acres for the four units is 2% of all mechanical treatment areas. The 15 acres on unstable lands receiving treatment is 1% of all mechanical treatment areas. Total area of unstable lands within all mechanical treatment areas is 66 acres, or 5% of all mechanical treatment areas.
The majority of the 15 acres of unstable lands proposed to be treated mechanically is by cable yarding in one unit in the Donahue area (2460) on a maximum of 9.2 acres. The remaining 5.7 acres are divided nearly equally between two mechanical road based units (2120, 2158), and one mechanical ground based unit (2119) in the Ti Creek area.

The very small number of acres where mechanical treatments may be applied (15 acres, 1% of all mechanical treatment areas), in tandem with other factors, results in minimal to low risk of impacts in the form of changes in rate or extent of landslide activity in the four unit areas. The focus of the project is to thin stands leaving the majority of trees, which greatly decreases the risk of landslide activation due to loss of root strength and increase in pore pressures from increased groundwater volume known to be associated with total loss of vegetation (Reid 2010, Ziemer 1981, Robichaud 2000, Bosch and Hewlett 1982). Forest wide standards and guides in the Klamath Land and Resource Management Plan limit

Table xx. Summary of Mechanical Treatments on Unstable Land Areas within Mechanical Treatment Areas.

Unit Treatment Type	Total Mech. Treatment Area (acres)	Total Unstable Area Within All Mechanical Treatment Units (acres)	Total Area of 4 Mech. Units wherein some Unstable Lands will be Treated (acres)	Total Area within the 4 Units That is Unstable Land (acres)	Total Area within the 4 Units That is Unstable Land Receiving Mechanical Treatments (acres)
Mastication	187	7.96	0	0.00	0
Mech - cable	103	20.8	20.4	18.6	9.2
Mech - ground-based	1,058	24.2	3.2	3.2	2.6
Mech - road-based	73	13.2	8.9	8.9	3.1
Totals	**1,420**	**66**	**32**	**31**	**15**

Unit Treatment Type	Of Total Mechanical Treatment Unit Area, % That is Unstable Land Area	Of Total Mechanical Treatment Unit Area, % Area That are Units wherein some Unstable Lands will be Treated	Of Total Mechanical Treatment Unit Area, % That is Unstable Land Area Receiving Mechanical Treatment
Mastication	4.3%	0.0%	0%
Mech - cable	20.2%	19.8%	8.9%
Mech - ground-based	2.3%	0.3%	0.2%
Mech - road-based	18.1%	12.3%	4.2%
Totals	**5%**	**2%**	**1%**

ground disturbance to 15%, and that a minimum of 50% of soil be covered with organic matter (USDA 1995a, 4-21), and project design features on unstable lands require compacted surfaces to be decompacted, and to have water bars installed. These mitigations greatly reduce concentrated flows, and promote infiltration thereby minimizing changes to groundwater routing, which can increase risk of landslide activation (Ziemer 1981, Reid 2010, Roering 2003).

Site specific details play a role in minimizing risk of impacts to unstable lands. The units in the Ti Creek area are within a large, landscape scale, deep-seated earthflow. Their location within the earthflow is in its center where its low gradient topography lends a greater degree of stability (Reid 2010, Montgomery and Dietrich 1994, Spittler 1989). The units are low gradient and slope away from the neighboring streams. In the ground based unit ground disturbance will limit compaction by working only from the road out to both sides along skids. The road based units will be causing ground disturbance via endline yarding from the road that will generate skid trails out from each side of the road for a certain distance only, and not in other parts of the unit. The need for water bars will be minimal as the two units encompass low gradient slopes. One of the road based units (2120) also allows for mechanical treatment by cable yarding within the outer 80 feet of the stream Riparian Reserve that overlaps with the unstable lands. Treatment in this very small areas (0.2 acres) will be minimal, and is on low gradient slopes reducing risk of landslide activity.

The cable unit in Donahue area (2460) lies within the headwall of a large, deep seated earthflow. It is generally very steep. Recent shallow landslide activity is evident in limited sections of the road fillslope that crosses the headwall. However, all 50 year old trees growing on the headwall are straight. This may suggest that the majority of topsoil was lost during prior logging events, and that the remaining risk of failure is by shallow debris slides associated with the road rather than large mass movement. In this unit as in the others, 40-60% of trees will remain to provide shear strength and cohesion to the slope reducing the risk of failure (Ziemer 1981, Reid 2010, Roering 2003, de la Fuente et. al. 2002). All activity will be excluded from the recently active features, and from the stream Riparian Reserve in the north half of the unit such that any potential landslide activation will not deliver to streams. The minor section of stream Riparian Reserve in the southern half of the unit is far from proposed cable corridor locations. This unit requires oversight prior to implementation to ensure corridor locations are placed for minimal risk.

Further risk of landslide activity is by intense storms. This trigger is unpredictable. Though, on average, 10-15 year magnitude storms are the most likely to produce mass movement (Spittler 1989, Wondzell and King 2003), actual storm intensities that can trigger landslides depend on antecedent and subsurface infiltration conditions (Iverson 2000, Roering and Jackson 2009). However, a major mitigating factor in reducing the risk of landslide activity is the prevention of high intensity fire itself through the proposed actions of fuels reduction and prescribed burning (Levitan 2014, Rolof et. al. 2005). The low burn intensities and retention of trees associated with the proposed fuels treatments minimize the longer term risks associated with high intensity burns such as decreased infiltration from hydrophobicity, and loss of root strength with vegetation clearing (Iverson 2000, Roering and Jackson 2009, Wondzell and King 2003, Ziemer 1981, de la Fuente et. al. 2002).

Cumulative Effects

A major mitigating factor in reducing the risks of accelerating landslide activity is the prevention of high intensity fire itself through the proposed actions of fuels reduction and prescribed burning (Levitan 2014, Rolof et. al. 2005). The low burn intensities and retention of trees associated with the proposed fuels treatments minimize the longer term risks associated with high intensity burns such as decreased infiltration from hydrophobicity, and loss of root strength with vegetation clearing (Iverson 2000, Roering and Jackson 2009, Wondzell and King 2003, Ziemer 1981, de la Fuente et. al. 2002).

While there are areas of concern where project effects, such as mechanical ground-based yarding, might have short-term deleterious effects, such as locally triggering slope instability if not performed according to appropriate design features, the consequences of no action might be more significant from a slope stability perspective. Notably, following the 2008 array of large fire complexes across the Klamath Mountains, reactivation of deep-seated landslides has been observed in a number of high severity burned areas (Mikulovsky et al, 2012). Common factors among these reactivations include stand-replacing (high or complete tree mortality) fire in late seral or old-growth stands, and deep-seated landslides (earthflows, block sides, rotational/translational complexes, etc.) on highly sheared or unconsolidated geologic types. In all documented Klamath Mountains cases in the 2012 paper, the geologic substrate was Rattlesnake Creek Terrane, frequently mélange, often serpentinized. In the Coast Ranges, Franciscan rock types that are also frequently mélanges were involved. These are both common bedrock types in the project area. Because the project area has been fire-excluded for a lengthy period, it is likely that wildfire in the area would spread rapidly and extensively, and would burn at high severity in areas that resemble those with the described re-activated landslides. It is reasonable to assume then, that treatments such as those proposed, if they prove effective at reducing fire risk, will provide safer access for firefighters to contain fire starts, reduce the overall pattern of high burn severity on the landscape, and be effective in helping maintain hillslope stability and landsliding rates within their range of historic variability, and meet the desired condition under Klamath Land and Resource Management Plan. If standards and guidelines, BMPs, and project design features are followed, negative effects to slope stability should be minimal or absent as compared to the likelihood that extensive landslide reactivation would be likely in the event of stand-replacing fire across much of the landscape.

Project Design Features

The following design features should help ensure that project activities do not compound or reactivate existing slope instability, or trigger new landslides.

- In areas mapped as large deep-seated earthflows, mechanical ground disturbance will occur only within the dormant area as determined by the forest geologist. Disturbance should be completely remediated by ripping or subsoiling compacted areas to restoring infiltration capacity, and by installing water bars on skid trails and landings. (is incorporated into project planning, not needed as a stand alone PDF).
- Active landslides, inner gorges, and active areas within large deep-seated earthflows that display recent active landslide features such as active scarps, tension cracks, very hummocky topography with leaning or distorted trees, or recent (bare or unvegetated) disruption by landslide activity, will be excluded from ground-based mechanical treatments. These features will be flagged in the field as “no-touch” areas to be excluded from units and include buffer distances prescribed by the forest geologist that prohibit removal of rooted vegetation by mechanical methods. (already exists as part of standards and guidelines).
- Prescribed fire will be allowed to move freely across the landscape under prescription and burn plan guidance. Ignition in sensitive areas such as active landslide features should be avoided. Concentrations of manually cut fuels should be moved at least two rooted tree widths, or 30-50 feet away from active landslide features as possible prior to ignition (incorporated into buffers around slides and are flagged in field).

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Analysis Framework: Statute, Regulation, LRMP, and Other Direction

The following statutory authorities govern geologic resources and services activities essential to Forest Service programs:

Forest and Rangeland Renewable Resources Planning Act of August 17, 1974 (RPA) (88 Stat. 476; 16 U.S.C. 1600-1614) as Amended by National Forest Management Act of October 22, 1976 (90 Stat. 2949; 16 U.S.C. 1609). This act requires consideration of the geologic environment through the identification of hazardous conditions and the prevention of irreversible damages. The Secretary of Agriculture is required, in the development and maintenance of land management plans, to use a systematic interdisciplinary approach to achieve integrated consideration of physical, biological, economic, and other sciences.

Asbestos Airborne Toxic Control Measure (ATCM) for Surface Application: The ATCM rule was adopted by the California Air Resource Board (CARB) in 1990 and amended in 2000. The amendment lowered the asbestos content to 0.25 percent for asbestos-bearing ultramafic rock materials used for surfacing applications subjected to vehicular, pedestrian or non-pedestrian use, such as cycling and horseback riding. In remote areas the naturally occurring asbestos (NOA) content can be as high as 1% without concern.

Federal Cave Resources Protection Act of 1988 (102 Stat. 4546; 16 U.S.C. 4301 et seq). This act provides that Federal lands be managed to protect and maintain, to the extent practical, significant caves.

Region 5 Regional Forester's Direction on Naturally Occurring Asbestos issued February 11, 2009: The regional forester provided direction on addressing NOA on National Forest lands in California. "Any land management decisions regarding NOA must be based on sound data and analysis. According to EPA, the scientific assessment and identification of actual public health risks associated with NOA is a complex and time intensive process. Until such studies are performed, the Region will not have definitive information regarding actual employee and public health risks posed by NOA on national forest lands. Therefore, no decisions are being made or direction issued at this point in time to restrict or alter public access to and/or recreational use of the national forests." The letter further directs forests to make the public aware of the potential risk of NOA and its presence on National Forest lands as well as guidance on how visitors can reduce their exposure to the substance.

Region 5 Regional Forester's Naturally Occurring Asbestos Clarification on Interim Direction issued June 30, 2009:

The last sentence (as quoted above) is directed at public access or recreational use that is currently permitted on the forests. Any new proposed activities or projects on the forests that require NEPA would analyze NOA just like any other environmental hazard or concern.

As an example, a forest would not add unauthorized trail segments to the travel management plan until analysis of the segment for NOA, water quality issues, fisheries or other issues of concern were analyzed.